Basic Nuclear Science Research and Education at the National Superconducting Cyclotron Laboratory at Michigan State University

NSCL Highlights

- **National User Facility serving over 200 Ph.D. scientists annually**
- **Premier US rare isotope research facility**
- **Studies of the origin of the elements, nuclear structure and reactions, and nuclei at the limits of stability**
- **Campus-based facility provides optimum synergy of research and education: ~100 student employees, including over 40 graduate students**

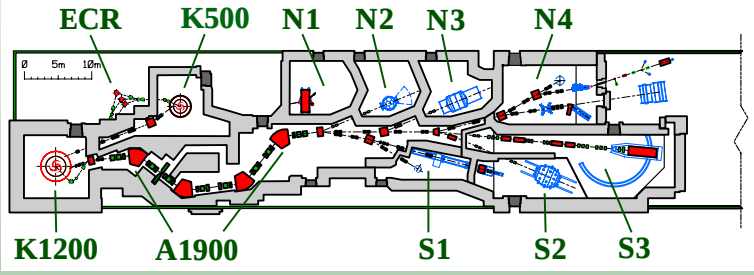
NSCL Research Programs

- **Experimental Nuclear Physics and Chemistry**
- **Theoretical Nuclear Physics**
- **Accelerator Physics**
- **Nuclear Astrophysics**
- **Atomic Physics**

Rare Isotope Beam Production at the NSCL

- stable ions of all elements are accelerated to 200 MeV/A using two coupled superconducting cyclotrons
- world's largest acceptance fragment separator, A1900, used to collect and separate fragmentation products
  - –increased luminosity from the use of thick secondary targets
  - –reduced background from in-flight tracking and identification of individual isotopes on a particle-by-particle basis
  - –short beam development times and low loses due to fast (sub-microsecond) and chemistry-independent separation and transport
- Increased beam intensity, beam energy, and separator acceptance leads to large gains in rare isotope intensity over previous facility

NSCL Facility Layout and Existing Experimental Apparatus



- **4π Array (N2)**
- **Scattering Chamber (N3)**
- **Gas Stopping System (N4)**
- **Sweeper Magnet (N4)**
- **RPMS (S1)**
- **Superball (S2)**
- **S800 Spectrograph (S3)**
- **Low-energy Beam Line and Ion Trap under development**
- **Moveable large solid-angle detectors: Miniball, NaI, Neutron Walls**

Education

There is a national need for Ph.D. nuclear scientists who have the know-how to address radiological and nuclear terrorism threats. 105 Ph.D.s based on NSCL research have been granted since 1992, ~10% of the US Ph.D. output in nuclear science.

Training tomorrow's nuclear and accelerator scientists

At the NSCL, graduate students and post-docs work hands-on with state-of-the-art electronic equipment and experimental tools, preparing them for future careers in research laboratories, academia, and industry.

Defining and demonstrating careers in nuclear science

One way the NSCL facilitates undergraduate research is through the Research Experience for Undergraduates (REU) program, sponsored by the National Science Foundation. REU students have actively participated in NSCL projects like the LASSA Si Array.

Improving nuclear science literacy

The Physics of Atomic Nuclei (PAN) program is a non-residential program for high school students and middle and high school physical science, chemistry, and physics teachers. The program introduces teachers and students to the fundamentals of the extremely small domain of atomic nuclei.

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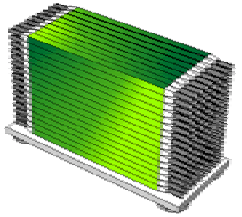
State-of-the-Art Radiation Measurement Devices

The detection of beta, gamma, and neutron radiations is critical for sensing radiological and nuclear threats. Researchers at the NSCL have considerable expertise in the detection of such radiations and have developed a number of advanced detection systems.

Segmented Germanium Array (SeGA)

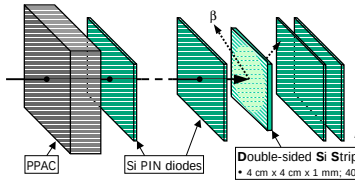
- 18 detectors compose the full array
- 32-fold segmentation for each germanium crystal
- gamma-ray tracking investigations

Modular Neutron Array (MONA)



- large area neutron detector
- 70% detection efficiency for neutron energies 50-250 MeV
- operated as time-of-flight wall

Beta Counting Station



- DSSD allows direct correlation of implants and decays
- used with both gamma and neutron detection

Neutron Ratio Observer (NERO)

- ^3He and BF_3 counters embedded in polyethylene matrix
- 46% detection efficiency for neutron energies 0.001-1 MeV

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